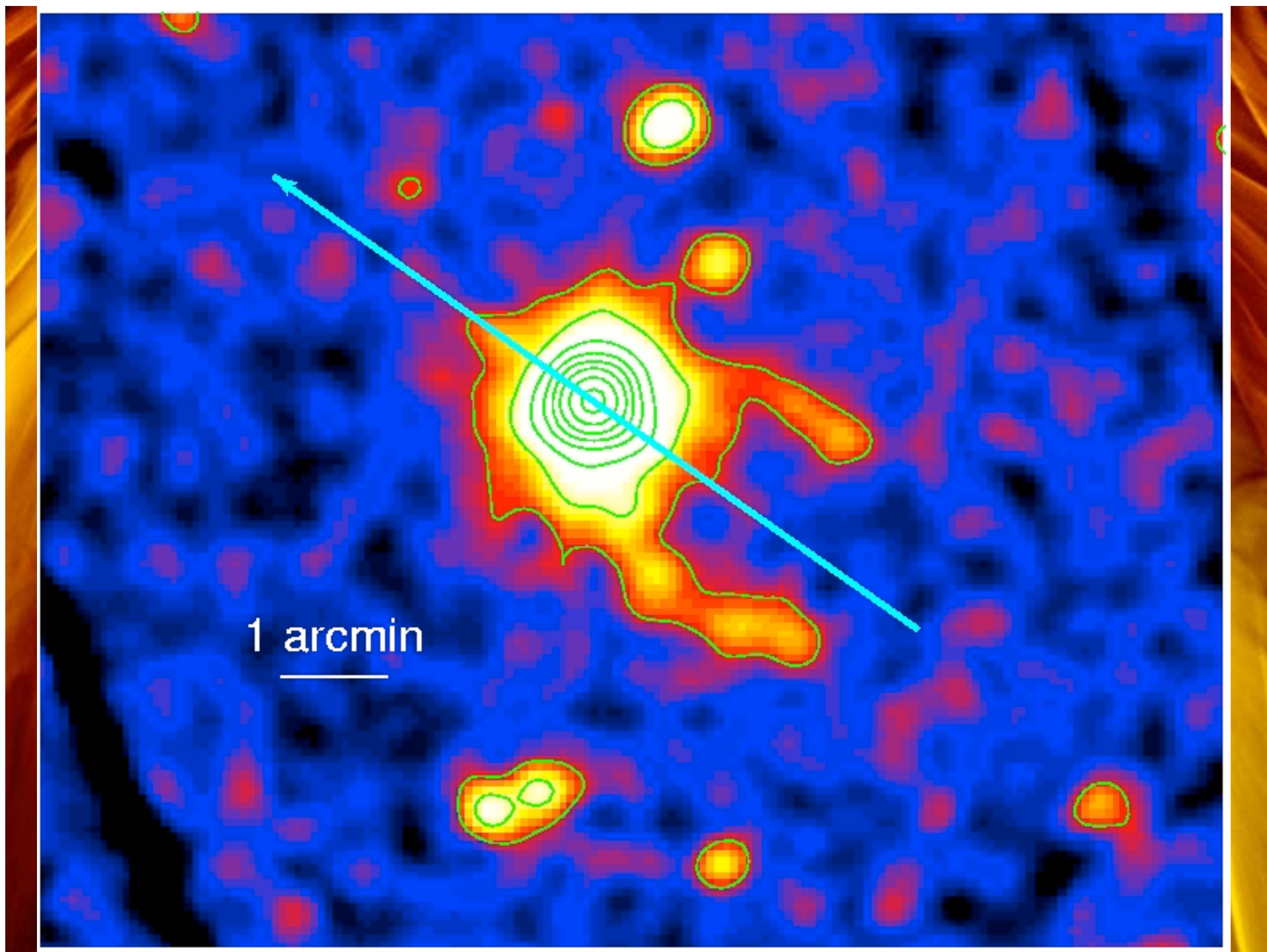




The XMM observation of Geminga

100 ksec of GT
time

Geminga strikes again



Energetics

$\dot{E} = 3 \times 10^{34} \text{ erg/sec}$

$D = 160 \text{ pc}$

$\mu = 170 \text{ mas/y}$

$v_{\text{tr}} = 120 \text{ km/sec}$

Geminga luminosity $3 \times 10^{31} \text{ erg/sec (0.1-5 keV)}$

Tails luminosity $6.8 \times 10^{28} \text{ erg/sec}$

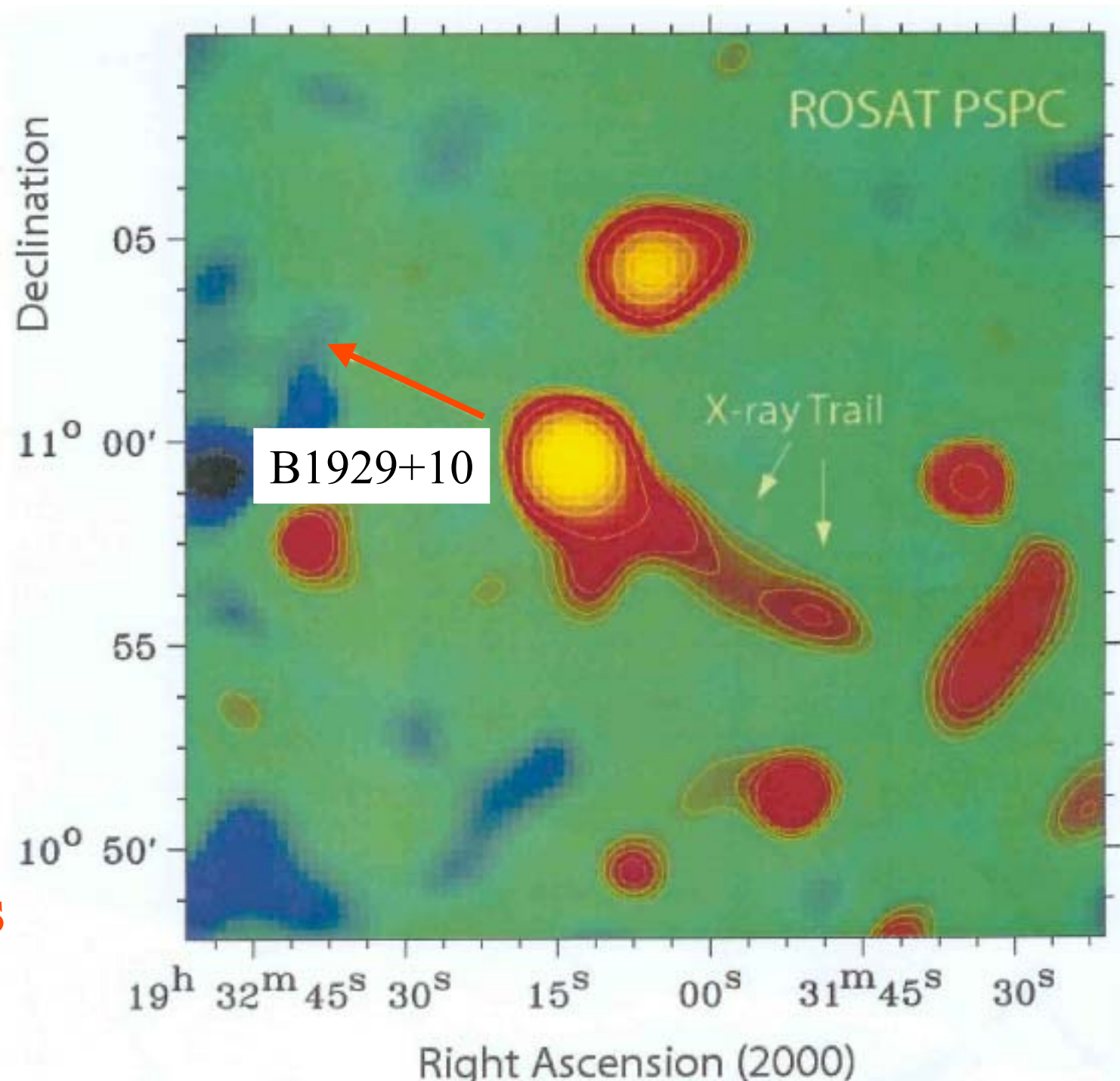
The tails account for $2 \times 10^{-6} \dot{E}$

What could this be ?



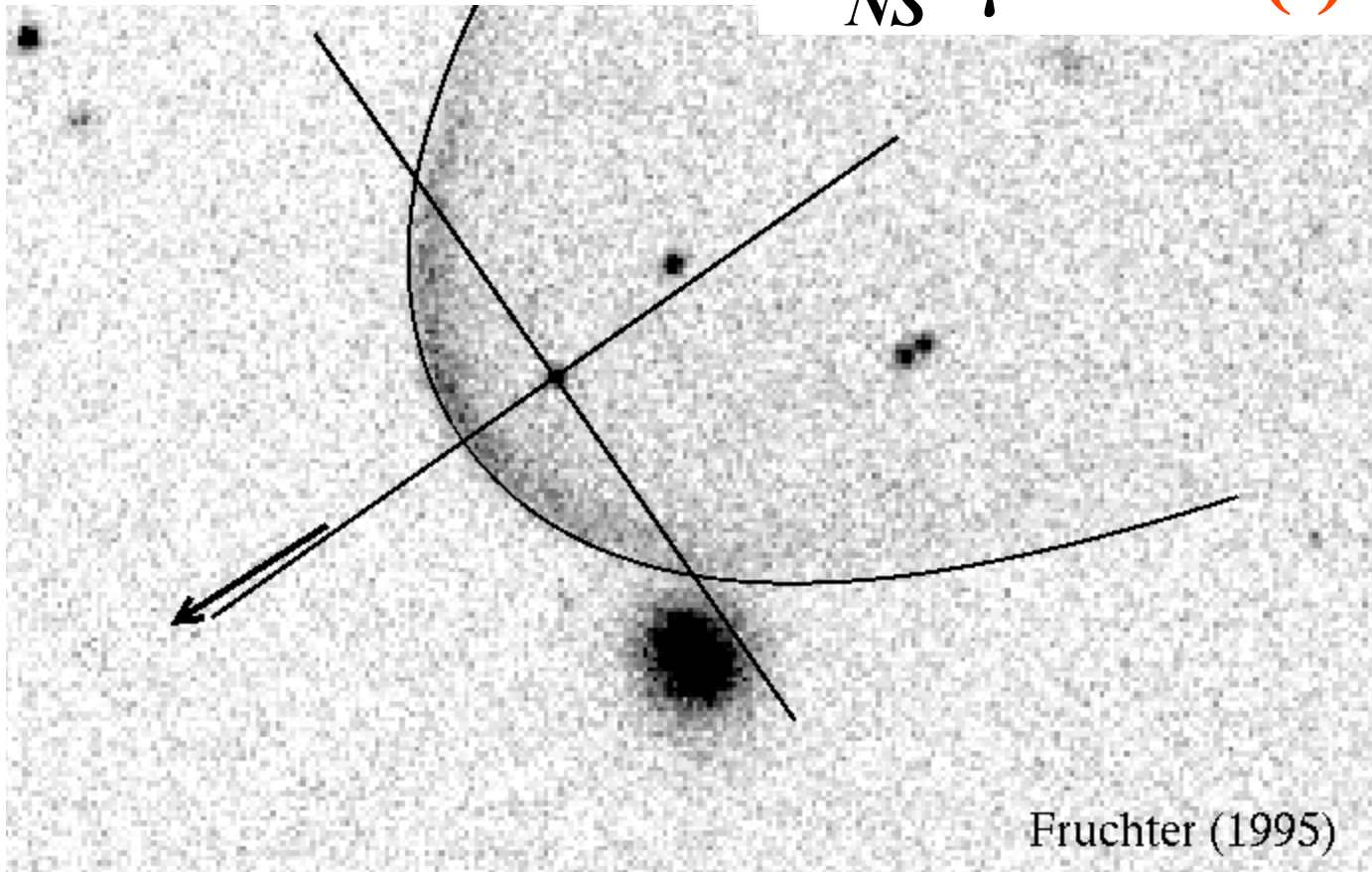
**A tail
like
this
one ?**

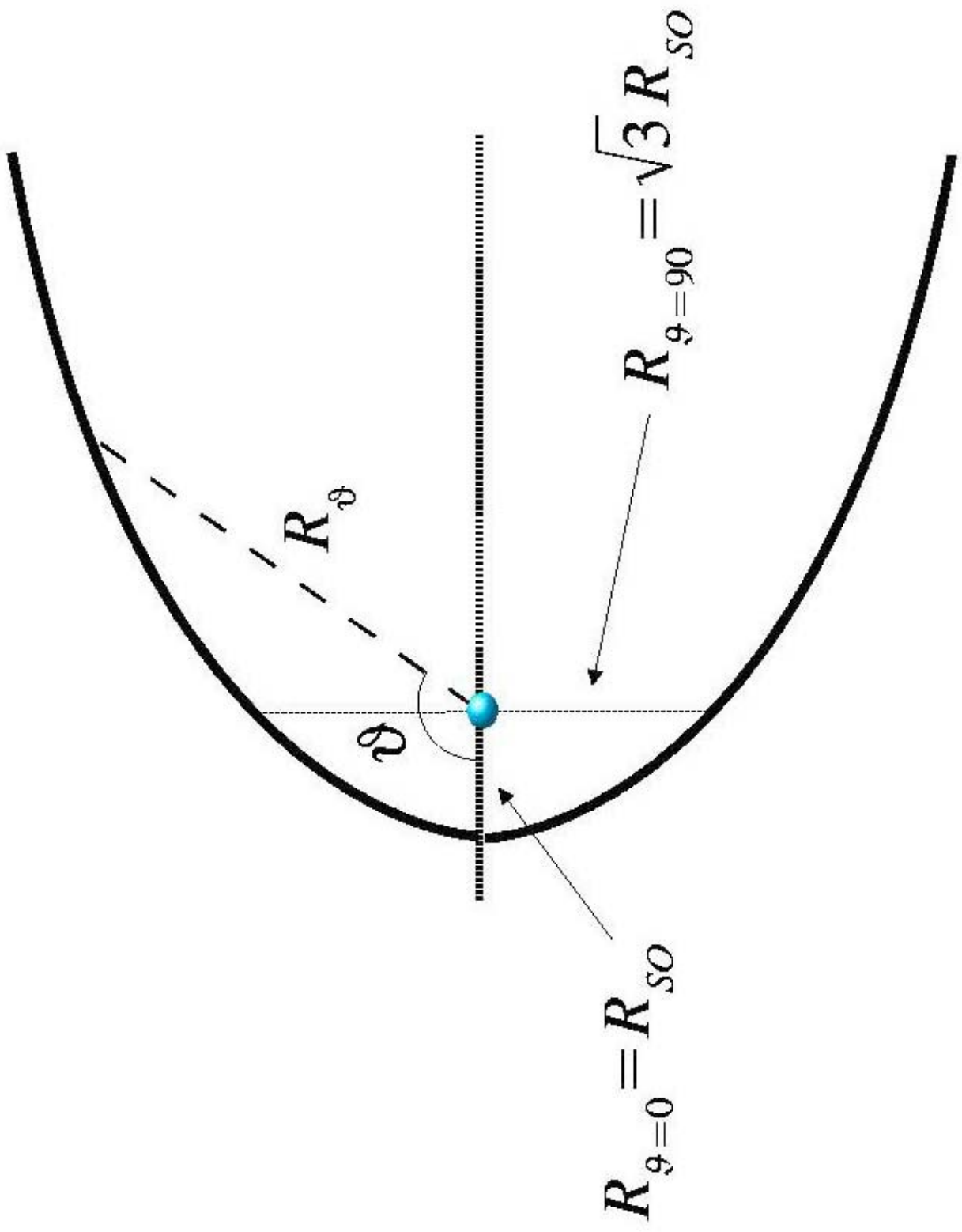
**No,
our tails
carry
% of E_{dot}
100 times
smaller**

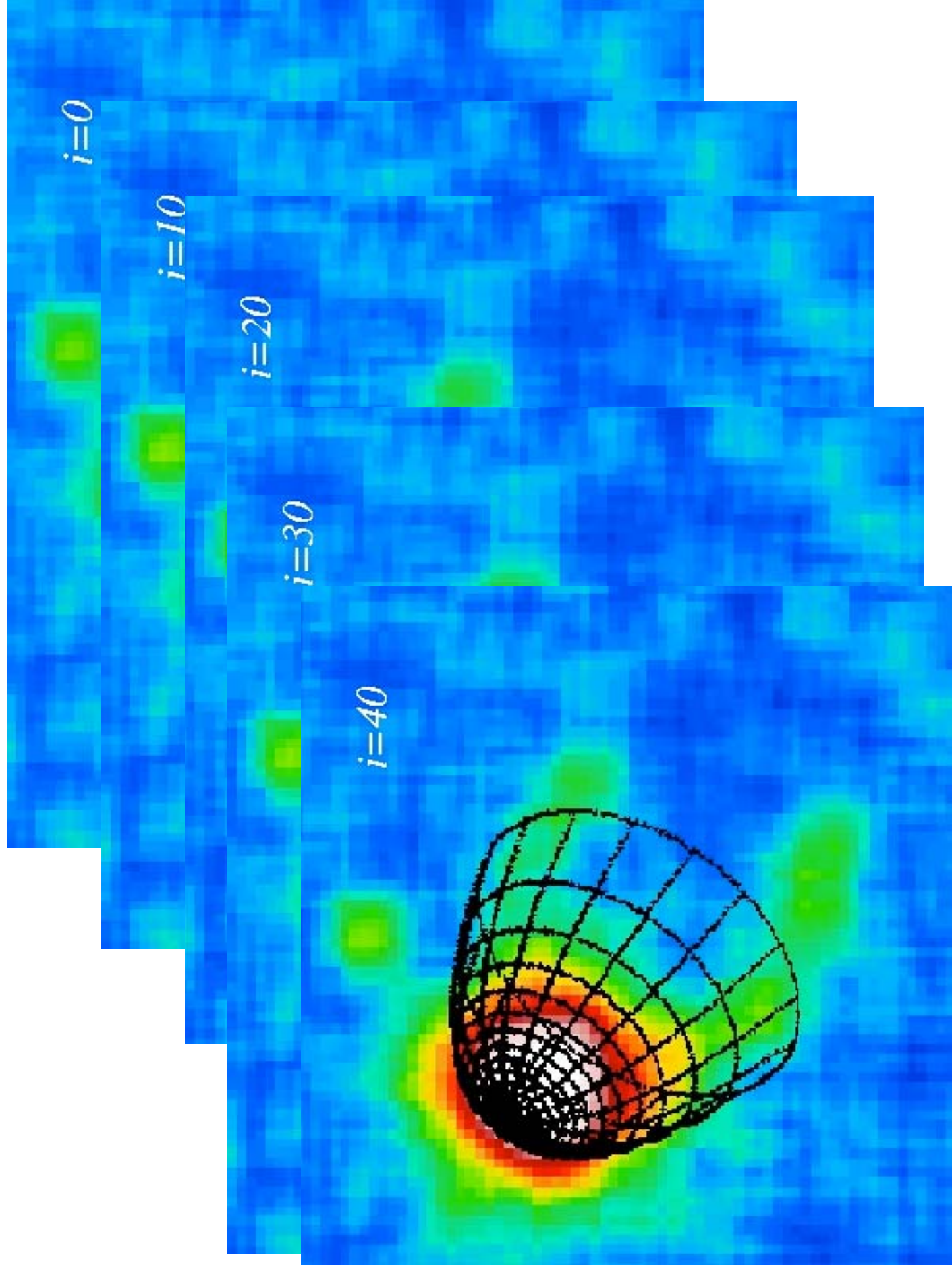


$$\frac{\dot{E}}{4\pi R_{SO}^2 c} = \rho_{ISM} V_{NS}^2 \frac{1}{15''}$$

$V_{NS} = \mu D / \cos(i)$

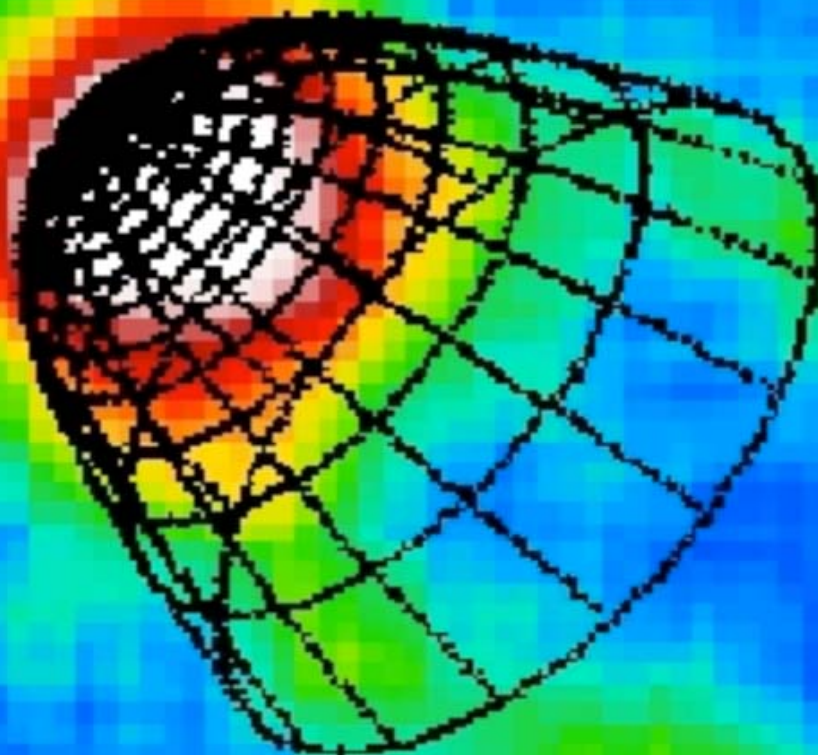


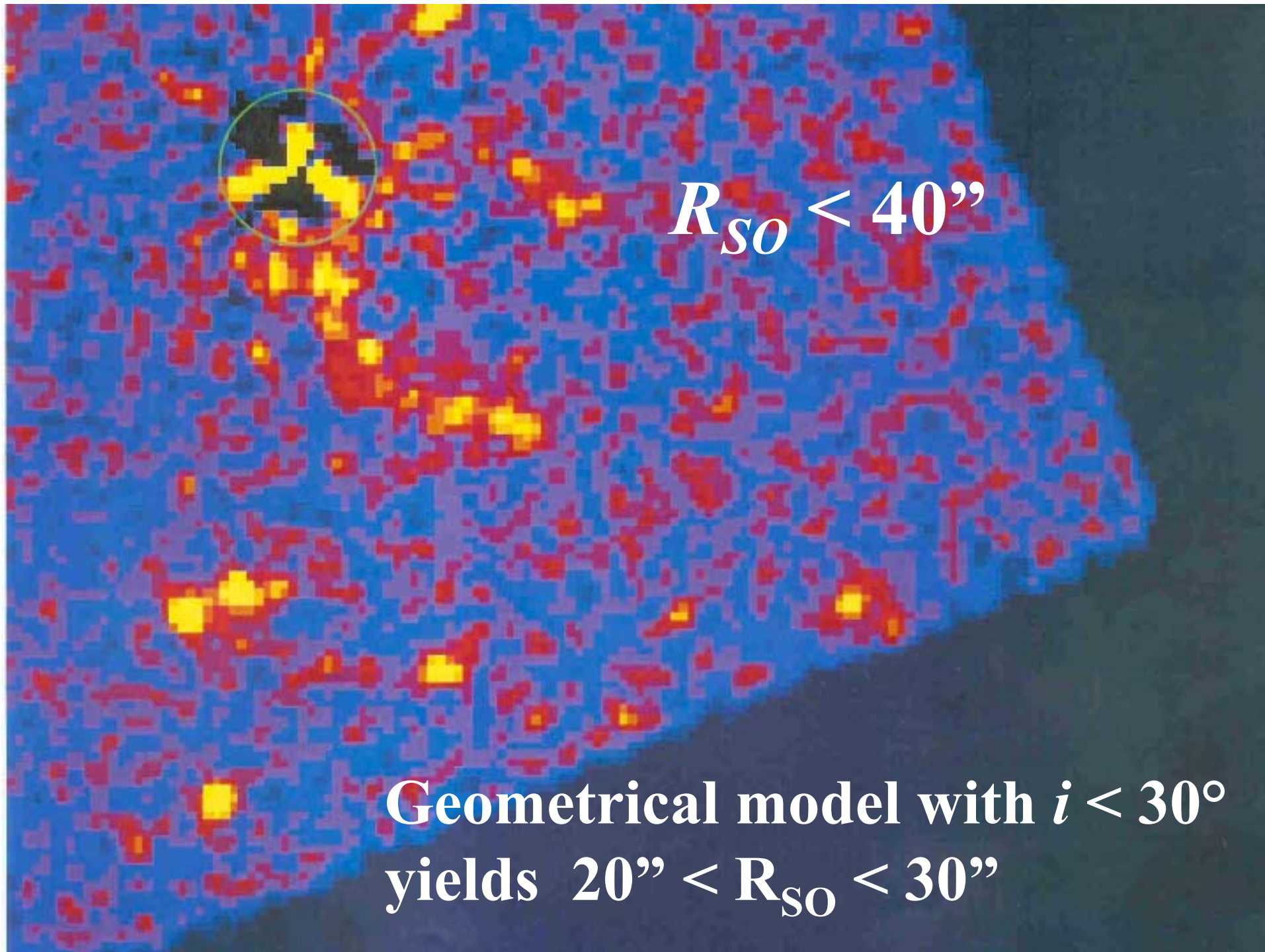




$i=30$

$i < 30^\circ$

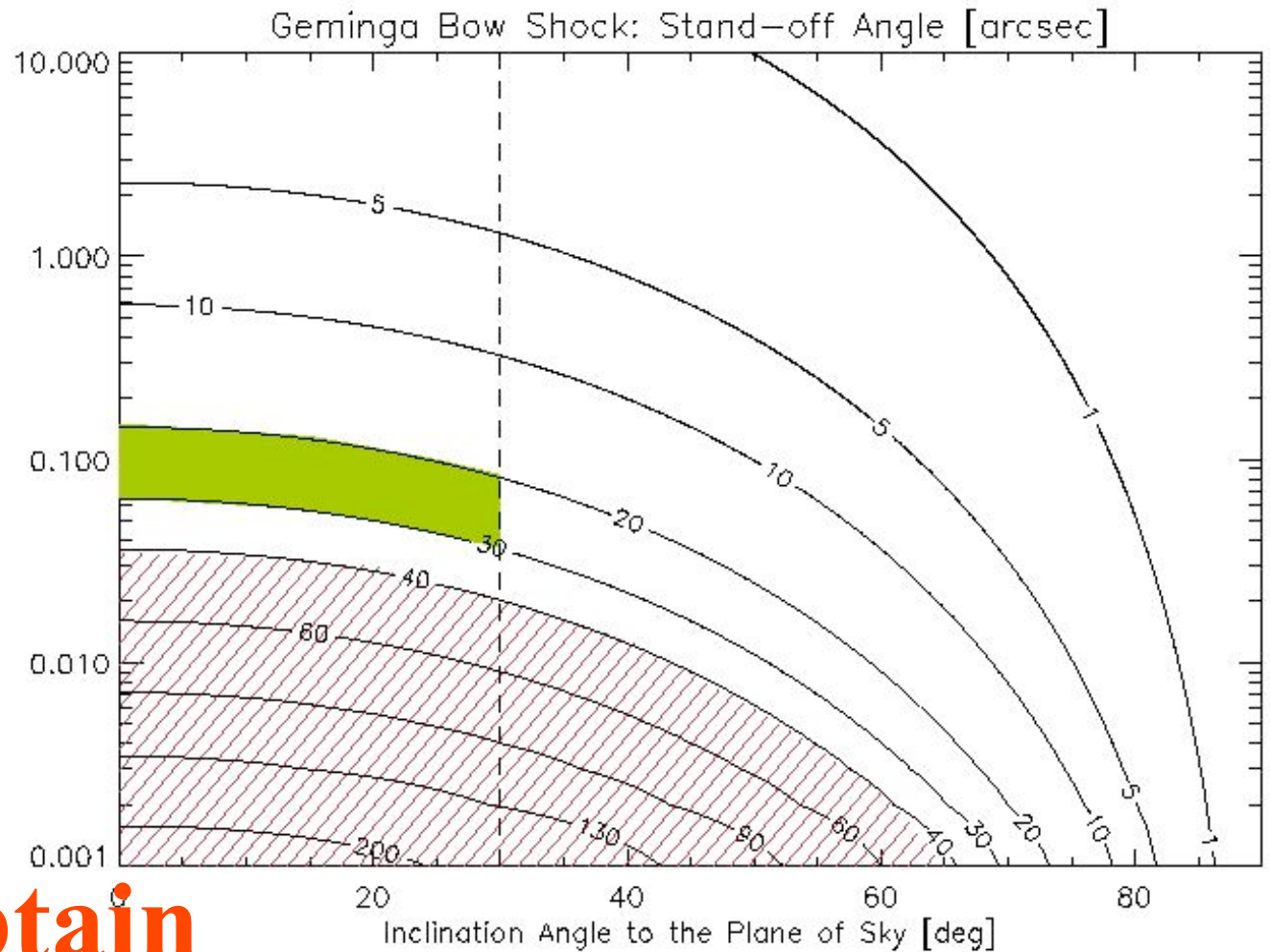




from bo

$$\frac{\dot{E}}{4\pi R_s^2}$$

ISM density [atomic mass/cm³]

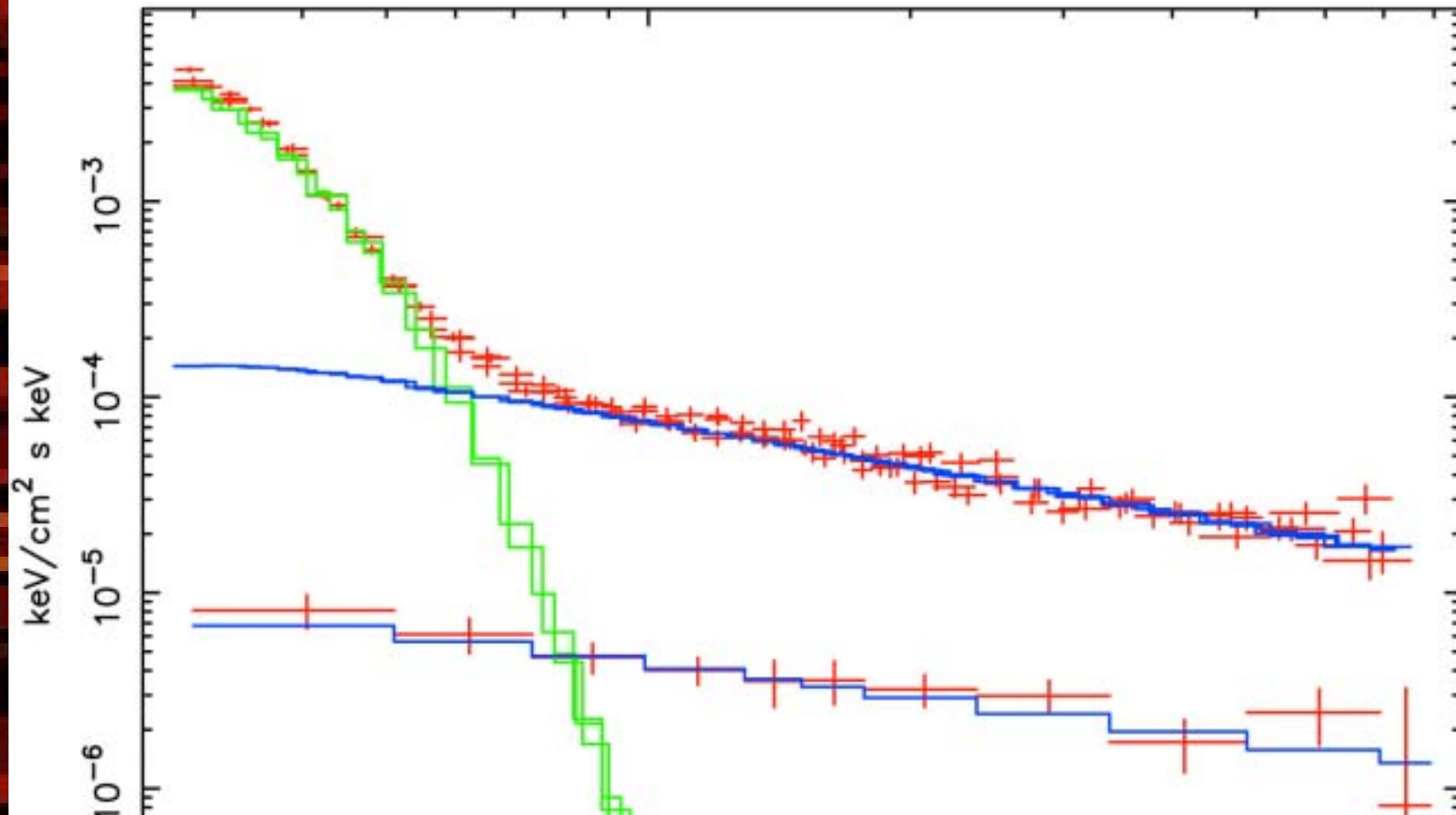


we can obtain

$$0.06 < \rho_{\text{ISM}} < 0.15 \text{ at/cm}^{-3}$$

which implies $7 < M < 20$

Geminga



Power law spectrum \rightarrow synchrotron radiation

\rightarrow need for electrons and magnetic field

From bow-shock theory

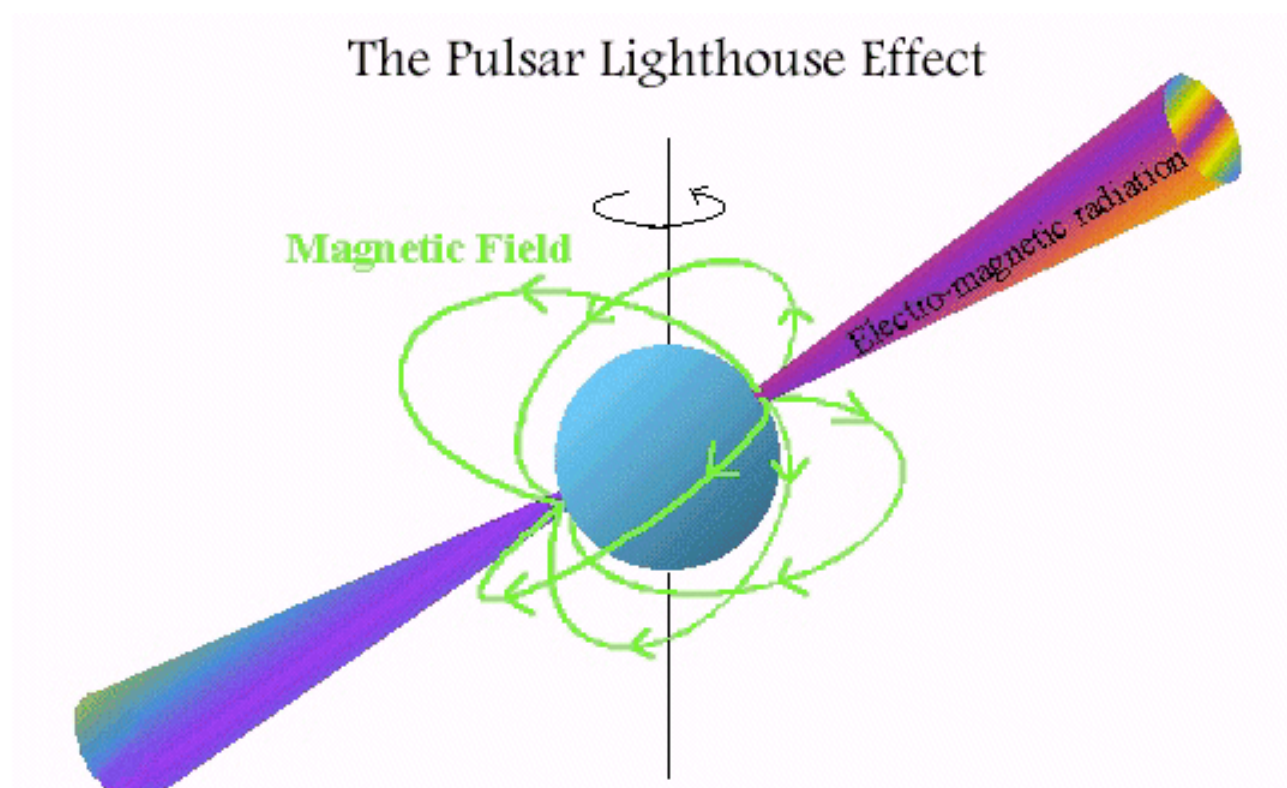
$$\rho_{\text{shock}} = 4 \rho_{\text{ISM}}$$

Since B is frozen-in

$$B_{\text{shock}} = 4 B_{\text{ISM}}$$

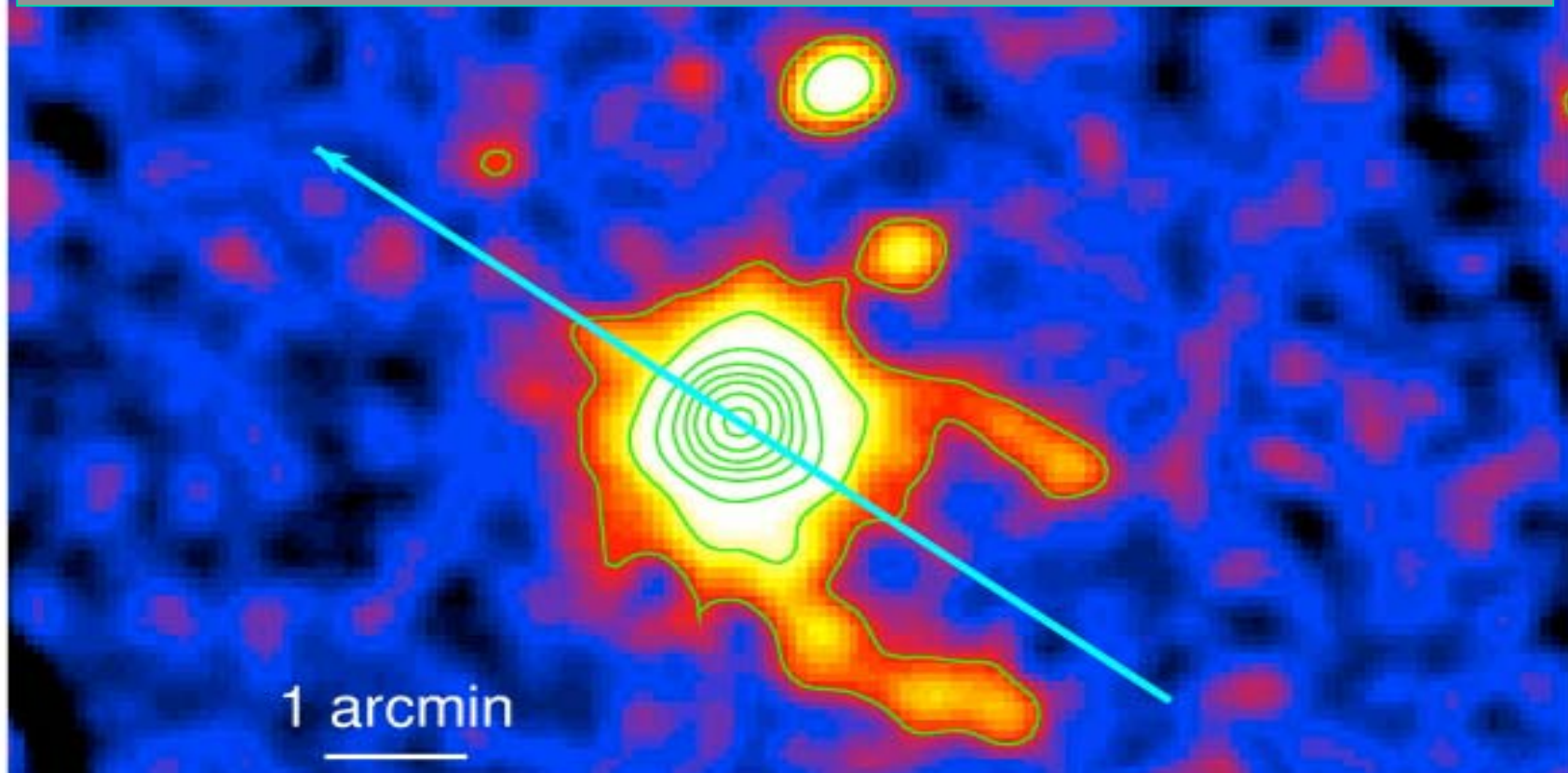
$$B_{\text{shock}} = 10^{-5} \text{ G}$$

**To produce keV photons in 10^{-5} G B field
one needs 10^{14} eV electrons**

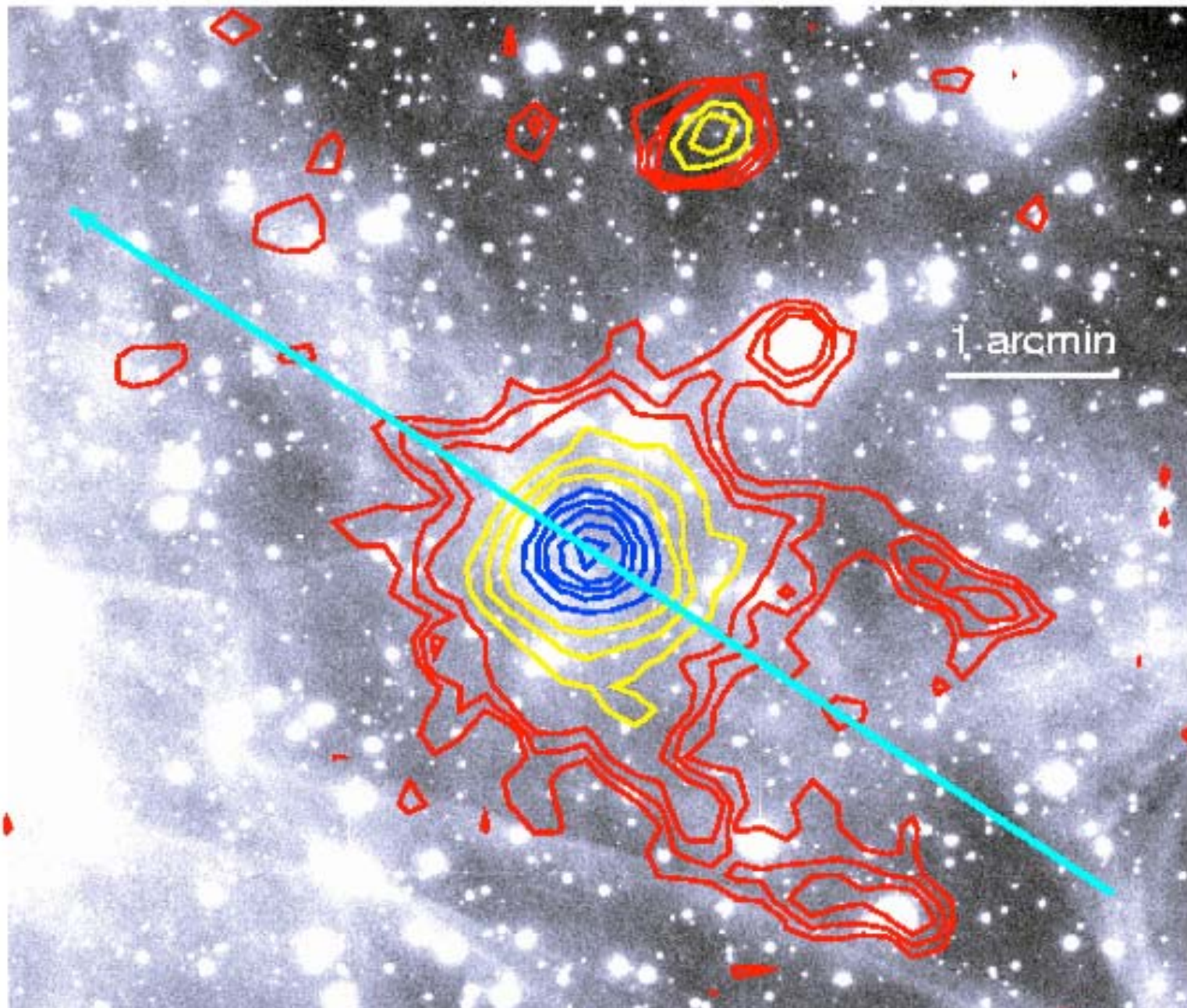


$$\Delta V_{\max} \sim \frac{\Omega^2 B_p R^3}{2c^2} \sim \frac{I\Omega\dot{\Omega}}{e\dot{N}_0} \sim 2 \times 10^{14} \text{ V} ,$$

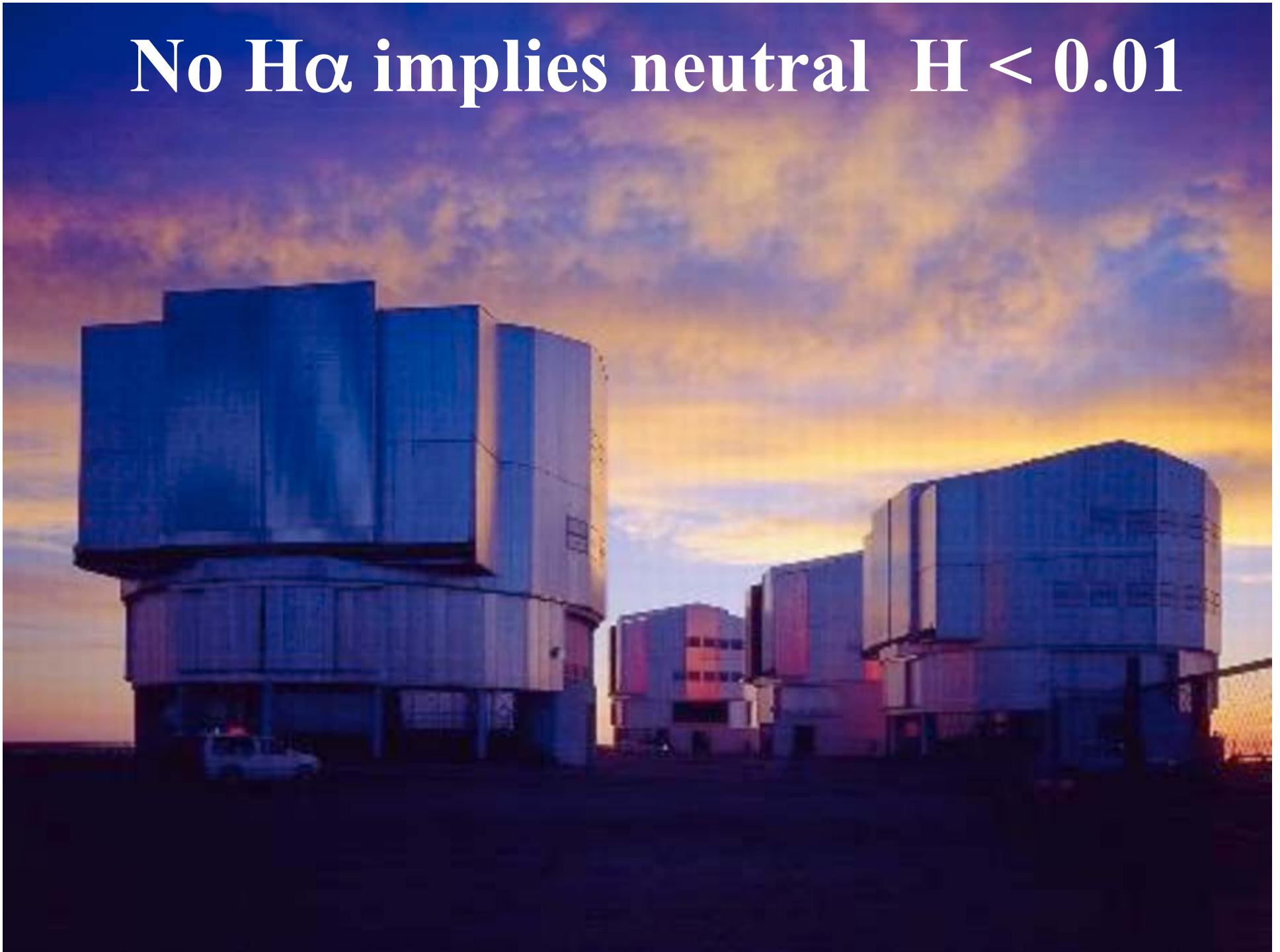
10^{14} eV electrons will have a Larmor radius of $3.4 \cdot 10^{16}$ cm \rightarrow thickness $6.8 \cdot 10^{16}$ cm $\rightarrow 27''$



10^{14} eV electrons will lose half of their energy in 800 y .
 $180'' / 170 \text{ mas/y} = 1,000 \text{ y}$



No $H\alpha$ implies neutral $H < 0.01$



Conclusions

Geminga accelerates electrons up to $E \sim 10^{14}$ eV

$$0.06 < \rho_{\text{ISM}} < 0.15 \text{ at/cm}^{-3}$$

$$B_{\text{ISM}} < 2\text{--}3 \times 10^{-6} \text{ Gauss}$$

The ISM is fully ionized by Geminga